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THE MATHEMATICS TEACHER

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WHAT SHOULD BE THE ESSENTIALS OF A COURSE IN MATHEMATICS FOR ELEMENTARY SCHOOLS IN NEW YORK CITY?

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Our individual answers to this question are largely controlled by our individual opinions, in which school tradition, or vocational demands, or mere predilection enter as largely determining factors. As yet we are not in possession of a sufficiently large body of scientifically treated data dealing with mathematical courses of study which we may use as norms for the determination of our answer. However, opinions on a particular subject of this kind are still of value in so far as they are based on intelligent experience with the factors specifically involved.

Practical people will probably agree on the following:

1. No course of study can be perfect or final. It attempts to meet a certain condition in a changing environment as best human experience can devise.

2. A course of study ought not to be the expression of an individual opinion as to how these conditions of the changing environment are to be met.

3. A course of study should be the outgrowth of the experiences of many individuals who are intimately concerned with the conditions which the course attempts to satisfy.

4. A course of study should be formulated for the purpose of satisfying the conditions of a specific educational situation. This implies that we preserve our poise and our balance; that

we perceive clearly the functioning values of the various factors that enter into the situation.

There are three commonly accepted principles underlying the formulation of a course of study:

I. The nature of the material selected is conditioned by the particular environment in which the pupils happen to be placed.

II. The selection of the material of instruction is conditioned partly by the future needs of the pupils, and partly by the mental abilities of the pupils at their several stages of development.

III. The arrangement of the material is conditioned by the capacities of the pupils; whence, as a corollary, arises the principle of arrangement with a view to the production of efficient results. I wish to consider each of these principles briefly in connection with the question propounded in the title of this paper.

I. The nature of the material from which we may select topics for a course and syllabus in mathematics for the elementary schools of New York City is well defined. We are in the midst of a vast center of commercial, manufacturing, mercantile and financial interests. These bring us into contact with the world at large at many points. The nature of the mathematical problems seems thus to be clearly indicated. Among the elements of this complex we find such matters as foreign exchange, domestic exchange, stocks and bonds, duties, taxes, brokerage, insurance of all kinds, industrial conditions that have quantitative relationships, agricultural problems that indirectly concern the city, and so one through a large list. And as a foundation for all this we have, as basic material, the fundamental operations with integers, with common fractions, and with decimals, the process of percentage, and the common measures in ordinary use.

II. But the regulative function of the principle of selection sharply limits the range of the field that may profitably be covered in the 850 hours allotted to mathematics during the eight years of our elementary school course. Hence arises the practical question, Out of all the interesting and possible facts and factors of our immediate environment that possess quantitative relationships, what elements may we safely and reasonably select as fit subject-matter of instruction for children ranging in age from 6 years through 14 or 15 years? As previously indicated, our controlling aim in selection has reference to two important conditions:

1. The satisfaction of the practical needs of the pupils to be fulfilled by a particular subject;

2. Furnishing material for suitable mental reactions, whence will arise valuable intellectual habits that are fostered by the functioning of such study. With respect to the intellectual habits fostered by the study of elementary mathematics in our schools, I presume that we shall agree on the two following as of greatest importance: (*a*) The ability to comprehend simple quantitative relationships; (*b*) The ability to resolve those relationships into a simpler form with facility and reasonable accuracy.

Unfortunately for the theorist, the controlling aim and its conditions can not be applied to our situation with the mathematical precision of a formula. It happens that certain practical considerations of a deterrent rather than regulative character must needs inhibit any tendency to select material of instruction in accordance with this aim and its conditions pure and simple.

In the first place, we find confronting us the given time element in the schedule of studies. What we would select for the purpose of fostering mathematical abilities as they could, might, or ought to be fostered, is one proposition. What we ought to select in order to meet the requirements of a time schedule that formally allows for mathematics 125 minutes per week for the first year, 150 minutes per week for the second through the fifth year, and 200 minutes per week for the sixth through the eighth year, or a total of 850 hours for the entire course, is an entirely different proposition.

In the second place, we should keep clearly in view the deterrent function of the teaching factor. Mathematics is, for most people, a dry and uninteresting subject. The great majority of our elementary school teachers really know very little of mathematics beyond the simplest arithmetic. Their preparatory mathematical outlook has seldom extended beyond the twilight horizon of introductory algebra and plane geometry, in the dim glimmer of which they once perhaps half discerned a few truths which have long since taken flight on the wings of forgetfulness.

Hence in the formulation of a course in mathematics we should remember that our teachers, while earnest and hard working and ambitious, are nevertheless not mathematical philosophers, nor are they philosophical mathematicians; for all of which we may, indeed, be truly thankful for the children's sake.

In the third place, we should not lose sight of the fact that a course of study formulated with the best of intentions, that a course perfectly practicable and educative under administrative conditions that effectively limit a class to 15 or 20 pupils who may be readily amenable to the ten commandments and the law dependent thereon, may be wholly visionary and futile when applied to our circumstances of administration. In our city schools we face registers of 50 and over, thus limiting opportunities for real teaching that begets power. Upon our administrative functions are imposed restrictions and limitations of a nature that cause to be retained in these overlarge classes the unfit, the wayward, the lazy, the indolent, and others of the submerged. These are plain facts, and in considering the making of a course of study we are obliged, as practical men, to face them.

In the fourth place, we find ourselves confronted by the present necessity of a uniform course of study for practically all elementary school pupils, with their multitude of individual differences, who are unregulated by a common ideal possible for adolescents, or for children of a common stock, of a common language, of a common tradition. This, therefore, postulates a course that shall be a feasible minimum requirement, with equal emphasis on " feasible " and on " minimum."

These four deterrent factors, viz., the time schedule, the teaching factor, the administrative problem referred to, and the present necessity for a uniform course of study for all sorts and conditions of children, are usually completely lost to sight by critics. But they are present, they are vital, and they make an insistent demand on our attention.

With these facts to control our ambitious fancies, I wish to present for your consideration the composite opinion of many teachers and principals relative to the topics that should be selected as a feasible and minimum basis for a course in mathematics for the elementary schools of New York City. This opinion is summarized in the following topics:

1. The four fundamental operations with integers.
2. The four fundamental operations with common fractions.
3. The four fundamental operations with decimal fractions.
4. Percentage as another aspect of fractions and decimals.
5. Very simple applications of percentage to real business situations in profit and loss, commercial discount, commission, taxes, duties, insurance, and simple interest; in all of which as a minimum requirement only the direct case is to be considered.
6. A working knowledge of the common measures in ordinary use in this city.

This general opinion is also in favor of the elimination of the following topics now directed to be taught in our elementary schools:

1. Algebra and inventional geometry.
2. The impossible mensuration now allotted to the 8*A* grade.
3. The metric system of weights and measures, for a working knowledge of which the science course may offer an opportunity.
4. The indirect cases in brokerage, taxes, commission, duties, insurance, commercial discount, and interest, seldom called for in even highly specialized business activities, and for which an understanding and a solution will be at hand when the business need therefor arises.
5. The ridiculous and time-consuming improbable topics in compound denominate numbers.
6. Longitude and time, which has its place in mathematical geography.
7. True discount.
8. A few odds and ends, such as the weight of potatoes, wheat, oats, etc., per bushel; troy weight; capacities of bins and cisterns; and the multiplication tables beyond 9 times.

In practice, many principals have been driven to the necessity of omitting various of these topics, though they zealously endeavor to have the entire course and syllabus taught as prescribed. With all of these topics eliminated, there would still remain much to be profitably taught that would be not only useful, but also highly educative as mathematical training. Indeed, it seems probable that a reduced course and syllabus would be much more useful and much more educative than the present overloaded and involved course. Our pupils would have a chance to use what they acquire, for there would be time for wide application and for intensive drill of real worth; and they would have a chance to think about things mathematical, for they would be rid of the perplexing confusion that in a great measure is due to the presence in our course of traditional curiosities and of a multiplicity of topics.

As to the elimination of algebra, I wish to state that the elementary school principals who have been consulted are practically unanimously in favor of such a step. The opinions of the high school people were ascertained by means of a questionnaire issued last May in which I propounded the three following questions:

1. What is your frank opinion relative to the preparedness of our grammar school graduates in the algebra work now outlined for the *7B* and *8A* grades, when the graduates reach high school?

2. Does our grammar school algebra assist pupils to a better understanding of high school algebra?

3. Would you and your mathematics teachers recommend that the study of algebra be postponed until the first term in the high school?

Of the 19 high schools then established in our city, replies were received from 13. All of the replies to the first question may be summarized in the brief statement, "variable and inconsequential." In answer to the second question, 8 answers were positively in the negative; 2 stated that the pupils were slightly helped; 2 reported the mathematics department to be divided in opinion; and just one answered in the affirmative. The replies to the third question were more decisive: 10 answered in the affirmative; 1 answered in the negative with the qualification that the algebra time should not be taken from the time allotted to arithmetic; 1 reported negatively without qualification; and 1 reported a division of opinion in the mathematics department.

As to inventional geometry, I may state that it has recently been incorporated in the new course of study in drawing where it quite properly belongs.

III. The third of the principles underlying the formulation of a course of study has special reference to the arrangement of the material of instruction. Such arrangement is dependent on the capacities of the pupils. The problem at this point is to grade the work with a twofold reference: (1) The matter should be arranged so as to accord with the abilities of the pupils; (2) the matter should be arranged so as to permit of the production of efficient results. It is in connection with this principle of arrangement that much hair-splitting arises, for here we trespass on the sacred domain of method. Shall we arrange the material spirally? Shall we revert to the older and substantial topical arrangement? Is a compromise preferable? The criticisms that come to me from intelligent critics who are daily laboring with our pupils, are unanimous on this one point; viz., that most of our children have mixed and hopelessly confused notions about various things mathematical, but definite and clearly defined notions about very few. Of course, there are all sorts of abilities, and even the same boy or girl develops in ability to comprehend mathematical relations as time goes on. Yet we are convinced that matters can be helped considerably by an arrangement of material that will give the teacher opportunity to develop the work more intensively than is now possible. Notions scattered over a large field, though we perceive the unity in diversity, do not appeal to the pupils in that philosophical way. The great majority of our pupils repeat glibly, perhaps, after us as we develop and interweave. But we all know how hopelessly they flounder when left alone. Too many topics and too many processes should not be crowded too thickly upon them—they are but children.

With these considerations in mind, I submit, as the result of my conferences with those who are in daily and intimate touch with the matters with which this paper deals, an arrangement of the subject-matter based approximately upon the following plan:

1st and 2d years: Much concrete work for the purpose of affording a basis for the fundamental operations with integers, and also for the purpose of fixing numerical facts. Limit the main work in the manipulation of numbers to the operations of addition and subtraction, within a gradually extended number range of four-place integers.

3d and 4th years: Development of the multiplication tables through 9's and their correlative division tables. Gradually apply these to the operations of multiplication first, and then to division, the overlapping of these two important processes not to occur until reasonable facility in the former with one or two-place multipliers has been gained. To the end of the 4th year limit multipliers and divisors to three places. Gradually extend the number range to seven-place integers. Introduce simple fractional notions in connection with the measures studied, and in the 4th year limit the fraction work to finding the business fractional parts of three-place numbers that are multiples of the denominators. The work in addition and subtraction extended within the number range indicated for the grades.

5th year: The chief work of the two grades of this year limited to common fractions of a simple type, such as are to be met with in ordinary transactions; and to decimals of not more than six places.

6th year: Opportunity should be given for clinching the work in fractions and decimals, and for correlating with these the operations of percentage as applied to situations within the pupils' experiences or understanding.

7th year: Application of the processes of percentage to the business situations previously mentioned, including simple interest, requiring the use of the direct case only.

8th year: Survey of the entire course with special reference to certain underlying general principles of arithmetic as applied to integers, fractions, decimals, and percentage, thus also affording an opportunity to the schools to render pupils assistance along the lines of their special needs after graduating.

From this very brief and sketchy outline there has been omitted a number of topics, not purely operative in character, that furnish the raw materials with which the operations deal; such as, problem work, its nature and scope; measurements; comparisons; business forms; as to which the time at my disposal does not permit of more than the passing mention that they would naturally find a proper place and use in the several grades.

For the purpose of giving definiteness, unity, and coherence to a course of study, I commend to your consideration the plan of the present Philadelphia course of study in mathematics for elementary schools, which appeals to me as the best of the many that I have examined. In addition to a statement of work to be done, there is printed in connection with each grade outline (1) clear and explicit directions for teaching the subject-matter, and (2) carefully selected type problems for regulating the degree of difficulty or of simplicity worth striving for. Something of this order of efficient control I suggest as worthy of consideration for the purpose of securing desirable homogeneity in the mathematical work of our schools.

To summarize: if I interpret the prevailing opinion of my colaborers correctly, the mathematical work of our elementary schools in New York City is in need of three distinct things:

1. Elimination of the traditional, the unnecessary, the too difficult.

2. Opportunity for an intensive treatment of topics, with due regard to reasonable correlation.

3. Suggestions as to the results that may reasonably be expected in the various grades.

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